(12) UK Patent Application (19) GB (11) 2 118 973 A

(21) Application No 8212094
(22) Date of filing 27 Apr 1982
(43) Application published 9 Nov 1983
(51) INT CL[3] C25D 5/18 7/00
(52) Domestic classification C7B 103 120 344 721 DR U1S 2066 C7B
(56) Documents cited GB 1366419 US 4088546 EP A 0056331
(58) Field of search C7B
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(54) Electrical connector and manufacture thereof

(57) A method for the connection of a metallic connector, the connector including a metallic member having a plurality of holes through a thickness of the member, to a metallic surface in order to provide an electrical contact between the connector and the surface, the method comprising the steps of:

(a) assembling and maintaining a surface of the member and the metallic surface in close proximal contact;

(b) arranging the assembly as a first electrode in an electroplating cell, the electroplating cell having a second electrode of a first metal and an electrolyte having in solution cations of the first metal; and

(c) passing a pulse current through the electroplating cell in a direction at least between the second and the first electrodes such that electrodeposition of atoms of the first metal occurs on the assembly, and substantially preferentially at surfaces which define the holes in the member, such that the member and the metallic surface become connected via a layer of the electrodeposited atoms.

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SPECIFICATION

Electrical connector and manufacture thereof

This invention relates to an electrical connector and manufacture thereof and in particular to a metallic electrical connector and a method for connection of the metallic electrical connector to a metallic surface by means of an electroplating method.

Known methods for the electrical connection of two metallic surfaces to give intimate contact between the surfaces such that the connection may not easily be broken by an applied force include soldering, spot welding or the use of an electrically conducting adhesive: hitherto it has not been practical to make a secure bond by electroplating.

An aspect of this invention is the use of a pulsed current in an electroplating bath having the combination of the metallic electrical connector and the metallic surface, which are closely proximal in the position in which they are to be joined, as an electrode. The pulsed current, and the provision of holes in the connector, gives rise to varying cation concentration gradients in the diffusion layer in the electrolyte closely proximal to the electrode. This variation in cation concentration at the surface of the electrode leads to preferential electrodeposition of metal atoms from the respective cations in the electrolyte on regions on the electrode corresponding to the holes in the connector.

The invention provides a method for the connection of a metallic connector, the connector including a metallic member having a plurality of holes through a thickness of the member, to a metallic surface in order to provide an electrical contact between the connector and the surface, the method comprising the steps of:

(a) assembling and maintaining a surface of the member and the metallic surface in close proximal contact;

(b) arranging the assembly as a first electrode in an electroplating cell, the electroplating cell having a second electrode of a first metal and an electrolyte having in solution cations of the first metal; and

(c) passing a pulse current through the electroplating cell in a direction at least between the second and the first electrodes such that electrodedeposition of atoms of the first metal occurs on the assembly, and substantially preferentially at surfaces which define the holes in the member, such that the member and the metallic surface become connected via a layer of th electrodeposited atoms.

A specific example of th present invention will now be described in greater detail with reference to and as illustrated in the accompanying drawings, in which:—

Figure 1 shows an electrical connector according to a preferred embodiment of the present invention; and

Figure 2 shows the relationship between current and time for an electroplating cell according to a preferred embodiment of the present invention.

Figure 1 shows an electrical connector including a plate 1 which is connected to an electrical cable 2 by a crimp 3 extending away from the general plane of the plate 1 and formed as an extension of an end portion 4 which is bent with respect to the rest of the plate 1 such that the cable 2/plate 1 connection does not lie in the plane of the plate 1. The plate 1 has a plurality of holes 5 in a generally ordered array, each hole extending completely through the thickness of the plate.

The plate 1 is preferably composed of copper.

Preferably the plate 1 has a thickness of up to 1 mm, the optimum thickness of a copper plate 1 being 0.5 mm.

Preferably the holes 5 in the plate 1 are circular in cross-section, as shown in Figure 1. Preferably the diameter of the holes 5 is between two to four times greater than the thickness of the plate 1 and the distance between the centres of adjacent holes is between three to three and a half times greater than the diameter of the holes 5.

In the case where the thickness of the copper plate 1 is 0.5 mm, the diameter of each hole 5 is preferably 1 mm and the separation of each hole 5 is 3.5 mm.

Preferably the undersurface of the plate 1 is substantially the same in shape as that of the metallic surface to which the plate is to be connected in accordance with the invention.

The plate 1 and the metallic surface are then assembled together and maintained in close proximal contact, with the respective surfaces to be connected being closely aligned.

Preferably, the plate 1 and the metallic surface are held in close contact by means of adhesive tape, with the tape preferably completely covering and masking off both the surface area of the connector, other than that surface of the plate 1 which has holes 5, and the surface area of the metallic surface, other than that covered by plate 1. The adhesive tape, and the adhesive employed should be chemically resistant to the electrolyte which is to be used.

The assembly of plate 1 and the metallic surface is then arranged as a first electrode in an electroplating cell. In this example, the electrolyte is copper sulphate solution acidified with sulphuric acid and a second electrode is composed of copper.

The electroplating cell is arranged such that a pulse current can flow through the electrolyte between the electrodes.

Preferably the pulse current characteristic is as shown in Figure 2, with the current being always positive or zero. In this instance, the first electrode is a cathode electrode and the second lectrode is an anode electrode.

However, alternatively the pulse current characteristic may be such that for periods of time which are substantially shorter than the pulse period, the current may be negative and therefore can flow in a reverse direction between the

electrodes such that, in these periods, the first electrode acts as an anode electrode and the second electrode acts as a cathode lectrode.

Referring again to Figure 2, the pulse width, as shown, preferably ranges between approximately 100 microseconds to 3 milloseconds and the pulse period as shown preferably ranges between approximately 200 microseconds to 4 millo-seconds.

The duty cycle of the pulse current is defined as:—

$$\text{Duty cycle} = \frac{\text{Pulse Width}}{\text{Pulse Period}} + 100\%$$

For the pulse current characteristic as shown in Figure 2 the duty cycle is between approximately 50% to 80% and is preferably approximately 50%.

The pulse width is chosen in accordance with the particular dimensions of the plate 1, and the holes 5 in plate 1, in order to give appropriately varying cation concentration gradients in the electrolyte diffusion layer closely proximal to the electrode, in order that electrodeposition preferentially occurs on the surface of the electrode in the holes 5 of plate 1.

In the pulse current arrangement alternative to that shown in Figure 2, when periodic current reversal occurs, the current may be reversed for, for example, up to 5% of the pulse period. This periodic current reversal aids the levelling of the surface of the electrode, thereby resulting in smooth and bright electrodeposits on the surface of the electrode.

Preferably, the peak pulse current density over the exposed area of plate 1 is between approximately 33—50 mA/cm².

Preferably, the electrolyte is maintained at a temperature of approximately 30—35°C during electrodeposition and the electrolyte is constantly stirred.

Preferably the electrodeposition is carried out for a period ranging between approximately 15 and 24 hours in order to achieve satisfactory integration of the plate 1 with the metallic surface, with the optimum time being 19 hours.

The electrolyte may also contain addition agents such as levellers or brighteners in order to result in a smooth and bright electrodeposit.

Claims

1. A method for the connection of a metallic connector, the connector including a metallic member having a plurality of holes through a thickness of the member, to a metallic surface in order to provide an el ctrical contact between the connector and the surface, the method comprising the steps of:

(a) assembling and maintaining a surface of the member and the metallic surface in close proximal contact;

(b) arranging the assembly as a first electrode in an electroplating cell, the electroplating cell having a second electrode of a first metal and an electrolyte having in solution cations of the first metal; and

(c) passing a pulse current through the electroplating cell in a direction at least between the second and the first electrodes such that electrodeposition of atoms of the first metal occurs on the assembly, and substantially preferentially at surfaces which define the holes in the member, such that the member and the metallic surface become connected via a layer of the electrodeposited atoms.

2. A method as claimed in claim 1 wherein the assembly functions as a cathode and the second electrode functions as an anode the pulse current only flowing from the anode to the cathode.

3. A method as claimed in claim 2 wherein the pulse current has a duty cycle of between 50 to 80 per cent.

4. A method as claimed in claim 3 wherein the pulse of current has a width of between 100 microseconds to 3 milliseconds.

5. A method as claimed in claim 4 wherein the period for the repetition of pulses is between 200 microseconds and 4 milliseconds.

6. A method as claimed in claim 5 wherein the pulse current density on the assembly has a value between 33 and 50 mA/cm².

7. A method as claimed in any preceding claim wherein the metallic member is a plate member and has an end adapted for connection to an electrical cable.

8. A method as claimed in claim 7 wherein the plate member has a thickness of up to 1 millimetre, each hole in the plate member having a diameter of between two to four times the thickness of the plate member, and centres of adjacent holes in the plate member being separated by a distance of between three to three and a half times the diameter of the holes.

9. A method as claimed in claim 8 wherein the plate member is composed of copper.

10. A method as claimed in claim 9 wherein the anode electrode is composed of copper and the electrolyte contains a solution of acidified copper sulphate solution.

11. A metallic member for connection to a metallic surface by means of a electroplating method as claimed in any preceding claim, the member comprising a plate member having an end adapted for connection to an electrical cable, the plate member having a plurality of holes through the thickness of the plate member, each hole in the plate member having a diameter of between two to four times the thickness of the plate member and centres of adjacent holes being separated by a distance of between three to three and one half times the diameter of the hol s.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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FIG. 1.

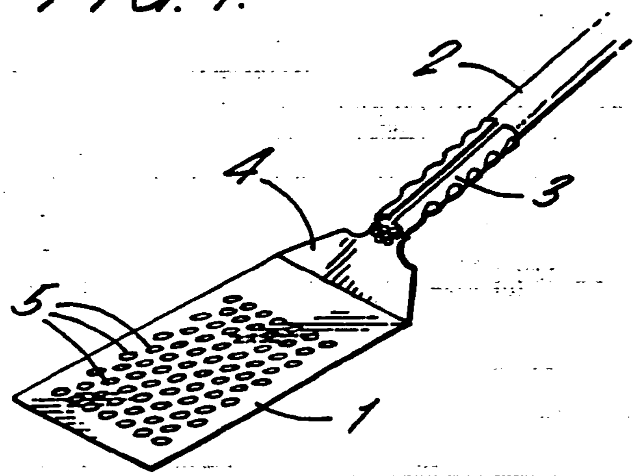

FIG. 2.